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ASTRONAUTICS

EVALUATION TEST OF

VERNIER LIQUID OXYGEN

SYSTEM BURST DIAPHRAGMS

27-21055

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1.0 OBJECT:

1.1 The object of this test was to develop a burst diaphragm suitable for service in the vernier liquid oxygen feed system.

2.0 CONCLUSIONS:

2.1 A suitable burst diaphragm was developed. The configuration chosen is shown in Dwg. 27-24055-13. Some of the principal factors affecting diaphragm design are listed below:

a) The diaphragm thickness remaining at the base of the groove is the main factor in determining the burst pressure.

b) Hinge width helps determine the ability of the diaphragm to remain with the rest of the diaphragm after rupture.

c) The diaphragm pad thickness determines its ability to fold over against the wall of the line.

3.0 DESCRIPTION OF SPECIMENS:

3.1 A total of 210 diaphragms were burst tested. These specimens were divided into eight basic groups. One group consisted of diaphragms per Dwg. 27-24055-13. The seven other groups consisted of generally similar specimens but with specific differences in configuration or methods of fabrication. These eight groups in turn were subdivided into smaller groups of specimens which included variations in the thickness of diaphragm material remaining at the base of the groove, width of the hinge pad, direction of the material grain with respect to the hinge and the test conditions to which they were subjected.

4.0 TEST PROCEDURE:

4.1 Burst Test:

4.1.1 The test requirements, and consequently the test procedure, were modified considerably during the course of

4.1.1 (Cont'd)

the test program. During the first half of the program, the various specimens were filled with liquid nitrogen and slowly pressurized to failure with nitrogen gas. During the second half of the test program, specimens were burst tested by one of the following methods:

a) Slowly pressurizing the specimen to failure with nitrogen gas.

b) Subjecting the specimen to a nitrogen gas impact load (press. rise approx. 30 psi per millisecond)

c) Slowly pressurizing the liquid nitrogen filled specimen with nitrogen gas.

d) Partly filling the specimen with liquid nitrogen and slowly pressurizing with nitrogen gas.

e) Partly filling the specimen with liquid nitrogen and applying an impact load with nitrogen gas. In addition, three burst tested specimens were subjected to a water flow test of approximately 16 gallons per minute for 45 minutes.

4.2 Test Equipment:

a) Pressure Gage by ACCO Helicoid, 0-60 psi range, 1/2 psi increments, Ser. No. 968

b) Pressure Gage by ACCO Helicoid, 0-300 psi range, 2 psi increments, Ser. No. 999

c) Pressure Gage by ACCO Helicoid, 0-400 psi range, 5 psi increments, Ser. No. 974

d) Pressure Gage by ACCO Helicoid, 0-1000 psi range, 10 psi increments, Ser. No. 80

e) Pressure Gage by Ashcroft, 0-2000 psi range, 20 psi increments, Ser. No. 1737

f) Pressure Regulator by Victor, 0-4000 psi inlet range, Ser. No. 893, 0-4000 psi outlet range, Ser. No. 892

4.2 (Cont'd)

g) Pressure Transducer by Statham, 0-1000 psi range, Ser. No. 6369

h) Valves by Security, Model 25020, Ser. No.'s M101 and M102

i) Valve- Solenoid by Marotta, Type MV-36, Ser. No. 1647

j) Recorder by Sanborn, Model 150, A.F. 765360-2.

5.0 DISCUSSION AND RESULTS:

5.1 Test results are shown in Tables 1 through 4. A graphic representation of the test results is shown in Graphs 1 through 4. Burst diaphragms to be used on the missile will conform to Convair Dwg. No. 27-24055-13. This diaphragm includes the following features:

a) Hinge width of 0.25 in.
b) Basic diaphragm thickness of 0.025 in.
c) Material thickness remaining at the base of the groove varying between 0.004 and 0.005 inches
d) Diaphragm grain direction- perpendicular to hinge

All of these dimensions and factors were varied during the test program. Additional variables included coined or machined grooves, rectangular or hemispherical shaped grooves, and various diaphragm pad patterns in the vicinity of the hinge. A rectangular-shaped, machined groove, terminating abruptly at the hinge, was chosen as the final configuration.

It was noted that the rupture pressure varied directly with the thickness of the diaphragm material remaining at the base of the groove. Impacting the specimen generally increased the rupture pressure by 100 to 200 psi. It was difficult to note the precise rupture pressure because the pressure continued to rise for a short time after impact type rupture. In these cases rupture pressure was considered to have occurred at the point where the slope of the pressure vs. time curve changed perceptably. High rupture pressures sometimes resulted in cracked hinges. A low rupture pressure often resulted

5.1 (Cont'd)

in an incomplete folding of the diaphragm pad. Because of these difficulties a wide hinge and a thin diaphragm were used.

6.0 DATA BOOK REFERENCE:

This report was prepared from test data recorded in Test Labs Engineering Note Book No. 7343.

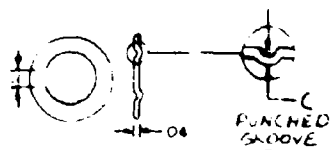
TABLE I

VERNIER LIQUID OXYGEN BURST DIAPHRAGM
BURST TEST RESULTS

NOTES:

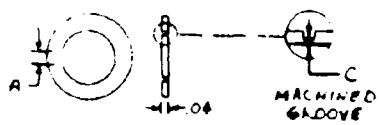
1 SPECIMEN MAT'L 5052 H34 AL ALLOY

2 SPECIMENS WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING TO FAILURE



DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM C (INCHES)	BURST PRESS. (PSIG)	COMMENTS
—	1	.006	—	PRESS TO 375 PSI NO RUPTURE
—	2	.008	580	
—	3	SPECIMEN NO 3 WAS A SPECIAL DIMPLED DIAPHRAGM PRESS TO 800 PSI WITHOUT RUPTURE		
—	4	.001	220	
—	5	.001	185	PAD TORE LOOSE AT HINGE
X	6	.0028 .004	360	
X	7	.0028 .004	280	

DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS
X	8	.0028 .004	250	
X	9	.0028 .004	295	
0	10	.004 .005	180	PAD NOT COMPLETELY FOLDED
0	11	.004 .005	170	PAD NOT COMPLETELY FOLDED
0	12	.004 .005	205	PAD NOT COMPLETELY FOLDED
—	13	.002	145	PAD NOT COMPLETELY FOLDED
6	25	.004	—	PRESS TO 600 PSI NO RUPTURE



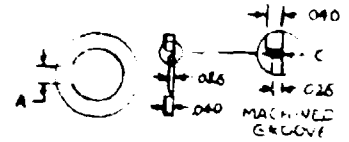
DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS
1	14	.12	.001	40	PAD NOT COMPLETELY FOLDED
1	15	.12	.001	30	PAD NOT COMPLETELY FOLDED
4	20	.12	.002	105	PAD FOLDING INCOMPLETE
4	21	.12	.002	125	PAD FOLDING INCOMPLETE
5	22	.18	.002	80	PAD FOLDING INCOMPLETE
5	23	.18	.002	90	PAD FOLDING INCOMPLETE
6	24	.125	.002	140	PAD FOLDING INCOMPLETE
7	26	.125	.003	125	PAD FOLDING INCOMPLETE

DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS
7	27	.125	.003	170	PAD FOLDING INCOMPLETE
8	28	.187	.003	145	PAD FOLDING INCOMPLETE
8	29	.187	.003	190	PAD FOLDING INCOMPLETE
8	30	.187	.003	115	PAD FOLDING INCOMPLETE
9	31	.25	.003	155	PAD FOLDING INCOMPLETE
9	32	.25	.003	145	PAD FOLDING INCOMPLETE
10	33	.187	.004	230	
10	34	.187	.004	215	PAD FOLDING INCOMPLETE

TABLE II

VERNIER LIQUID OXIGEN BURST DIAPHRAGM

BURST TEST RESULTS

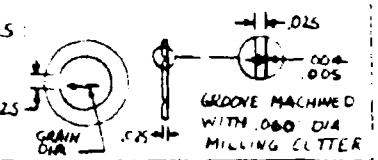


NOTES:

1. SPECIMEN MAT'L 5052H-34 AL. ALLOY
2. SPEC 35-47 WERE FILLED WITH LIQUID NITROGEN & SLOWLY PRESSURIZED TO FAILURE

DESIGN GR IDEN. NO	TEST LAB IDEN. NO	DIM. A (INCHES)	DIM. C (INCHES)	BURST PRESS (PSIG)	COMMENTS
11	35	.12	003	155	PAD FOLDING INCOMPLETE
11	36	.12	003	150	PAD FOLDING INCOMPLETE
11	37	.12	003	100	PAD FOLDING INCOMPLETE
12	38	12	004	160	PAD FOLDING INCOMPLETE
12	39	12	004	145	PAD FOLDING INCOMPLETE
12	40	12	004	120	PAD FOLDING INCOMPLETE
13	41	.18	003	70	PAD FOLDING INCOMPLETE
13	42	18	003	50	PAD FOLDING INCOMPLETE
13	43	.18	003	230	
13	44	.18	003	60	PAD FOLDING INCOMPLETE
14	46	18	003	110	PAD FOLDING INCOMPLETE
14	45	.18	004	295	
14	47	18	004	310	

NOTE: SPEC 160-189 WERE BURST BY ONE OF THE FOLLOWING METHODS:
(a) SLOWLY INC NI GAS PRESS, (b) IMPACTING SPEC WITH NI. GAS
(c) SLOWLY INC. PRESS OF SPEC PARTLY FILLED WITH LIQUID NITROGEN
(d) IMPACTING SPECIMEN PARTLY FILLED WITH LIQUID NITROGEN



DESIGN GR IDEN. NO	TEST LAB IDEN. NO.	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
GIT4	180	STATIC NITROGEN GAS	320	
GIT4	181	STATIC NITROGEN GAS	290	
GIT4	182	STATIC NITROGEN GAS	275	CRACKED HINGE
GIT4	183	NITROGEN GA IMPACT	320	
GIT4	184	NITROGEN GAS IMPACT	325	SEVERELY CRACKED HINGE
GIT4	185	STATIC LIQUID NITROGEN	290	
GIT4	186	STATIC LIQUID NITROGEN	295	
GIT4	187	STATIC LIQUID NITROGEN	320	
GIT4	188	LIQ NI & NI GAS IMPACT	410	SEVERELY CRACKED HINGE
GIT4	189	LIQ NI & NI GAS IMPACT	260	

TABLE III (1 OF 3)

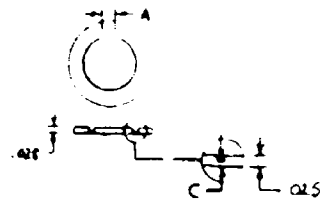
VERNIER LIQUID OXYGEN BURST DIAPHRAGM

BURST TEST RESULTS

NOTES:

1 SPECIMEN 1941 L 5052H 34 AL ALLOY

2 SPECIMENS 48 TO 75 WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE



DESIGN GP IDEN NO.	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS	DESIGN GP IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS
1A	48	125	003	165	PAD FOLDING INCOMPLETE	1C	70	18	004	200	
1A	49	125	003	110	PAD FOLDING INCOMPLETE	1D	71	18	004	190	
1A	50	125	003	40	PAD FOLDING INCOMPLETE, FAILURE NOT AT PAD FOLD	1D	76	18	004	230	
1A	51	125	003	70	PAD FOLDING INCOMPLETE, FAILURE NOT AT PAD FOLD	1D	77	18	004	230	
1A	52	125	003	160	PAD FOLDING INCOMPLETE	1C	78	18	004	205	
1B	54	18	003	170		—	79	18	004	195	
1B	55	18	003	185		—	80	18	004	160	
1B	56	18	003	150	PAD FOLDING INCOMPLETE	—	81	18	004	SPEC PRESS TO 4X AI (NO BURST)	
1B	57	18	003	160		—	82	18	004	155	
1B	58	18	003	205		—	83	18	004	110	
1B	72	18	003	230		—	84	18	004	155	
1B	73	18	003	255		—	85	18	004	320	
1B	74	18	003	260		—	86	18	004	155	
1B	75	18	003	245		—	87	18	004	195	
1C	59	125	004	175		—	88	18	004	180	
1C	60	125	004	270		—	89	18	004	195	
1C	61	125	004	165		—	90	18	004	230	
1D	65	18	004	155		—	91	18	004	220	
1D	66	18	004	175		—	92	18	004	205	
1D	67	18	004	340		—	93	18	004	210	
1D	68	18	004	SPEC PRESS TO 500 PSI (NO BURST)		—	94	18	004	165	
1D	69	18	004	240		—	95	18	004	215	

TABLE III (2 OF 3)

VERNIER LIQUID OXYGEN BURST DIAPHRAGM BURST TEST RESULTS

NOTES:

1. SPECIMENS 105, 111 & 112 WERE SUBJECTED TO A WATER FLOW TEST OF APPROX. 16 GAL./MIN FOR 45 MIN AFTER BURST TEST THERE WAS NO APPARENT DAMAGE
2. MAT'L GRAIN OF SPEC. 130-137 WAS PARALLEL TO HINGE RANDOM IN EARLIER SPECIMENS
3. SPEC. 96-115 & 125-129 WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE. THE REMAINING SPECIMENS OF TABLE 3 WERE TESTED BY ONE OF THE FOLLOWING METHODS (a) SLOWLY INCREASING NITROGEN GAS PRESS, (b) IMPACTING SPECIMEN WITH NITROGEN GAS, (c) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN & SLOWLY INCREASING NITROGEN PRESS, (d) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN & IMPACTING SPEC WITH NITROGEN GAS (EXCEPT SPECIMENS 116-124 WHICH WERE FULL OF LIQUID NITROGEN).

DESIGN GR IDEN. NO	TEST LAB IDEN NO.	DIM. A (INCHES)	DIM. C (INCHES)	BURST PRESS (PSIG)	COMMENTS
—	96	.18	.004	215	
—	97	.18	.004	225	
—	98	.18	.004	160	
—	99	.18	.004	215	
—	100	.18	.004	190	
—	101	.18	.004	90	PAD FOLDING & IMPACT
4-5	102	.18	.004 .005	190	
4-5	103	.18	.004 .005	195	
4-5	104	.18	.004 .005	215	
4-5	105	.18	.004 .005	185	
4-5	106	.18	.004 .005	225	
4-5	107	.18	.004 .005	190	
4-5	108	.18	.004 .005	200	
4-5	109	.18	.004 .005	210	
4-5	110	.18	.004 .005	225	
4-5	111	.18	.004 .005	200	
4-5	112	.18	.004 .005	210	
4-5	113	.18	.004 .005	225	
4-5	114	.18	.004 .005	230	
4-5	115	.18	.004 .005	190	

DESIGN GR IDEN NO.	TEST LAB IDEN NO.	DIM. A (INCHES)	DIM. C (INCHES)	BURST TEST CONDITIONS	BURST PRESS (PSIG)	COMMENTS
—	116	.18	.004 .005	LIQ NI & NI GAS IMPACT	320	
—	117	.18	.004 .005	LIQ NI & NI GAS IMPACT	460	
—	118	.18	.004 .005	LIQ NI & NI GAS IMPACT	320	
—	119	.18	.004 .005	LIQ NI & NI GAS IMPACT	240	
—	120	.18	.004 .005	LIQ NI & NI GAS IMPACT	280	
—	121	.18	.004 .005	LIQ NI & NI GAS IMPACT	340	
—	122	.18	.004 .005	LIQ NI & NI GAS IMPACT	325	
—	123	.18	.004 .005	LIQ NI & NI GAS IMPACT	320	
—	124	.18	.004 .005	LIQ NI & NI GAS IMPACT	315	
—	125	.18	.004 .005	STATIC LIQUID NITROGEN	270	
—	126	.18	.004 .005	STATIC LIQUID NITROGEN	180	
—	127	.18	.004 .005	STATIC LIQUID NITROGEN	205	
—	128	.18	.004 .005	STATIC LIQUID NITROGEN	225	
—	129	.18	.004 .005	STATIC LIQUID NITROGEN	280	
T4	130	.18	.004 .005	STATIC NITROGEN GAS	170	
T4	131	.18	.004 .005	STATIC NITROGEN GAS	195	
T4	132	.18	.004 .005	STATIC NITROGEN GAS	175	
T4	133	.18	.004 .005	STATIC NITROGEN GAS	165	
T4	134	.18	.004 .005	STATIC NITROGEN GAS	185	
T4	135	.18	.004 .005	STATIC NITROGEN GAS	200	
T4	136	.18	.004 .005	LIQ NI & NI GAS IMPACT	380	
T4	137	.18	.004 .005	NITROGEN GAS IMPACT	300	

TABLE III (3 OF 3)

VERNIER LIQUID OXYGEN BURST DIAPHRAGM

BURST TEST RESULTS

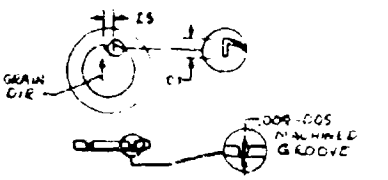
DESIGN OR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	GRAIN DIR TO FILLET HINGE	BURST TEST CONDITIONS	BURST PRESS (PSIG)	COMMENTS
T4	138	.18	.004 .005	∥	NITROGEN GAS IMPACT	300	
T4	139	.18	.004 .005	∥	LIQ N₂ & N₂ GAS IMPACT	300	
T2	140	.25	.004 .005	∥	STATIC NITROGEN GAS	205	
T2	141	.25	.004 .005	∥	STATIC NITROGEN GAS	170	
T2	142	.25	.004 .005	∥	STATIC NITROGEN GAS	185	
T2	143	.25	.004 .005	∥	STATIC NITROGEN GAS	205	
T2	144	.25	.004 .005	∥	STATIC NITROGEN GAS	175	
T2	145	.25	.004 .005	∥	STATIC NITROGEN GAS	220	
T1	153	.25	.004 .005	⊥	STATIC NITROGEN GAS	215	27-24055-6
T1	154	.25	.004 .005	⊥	STATIC NITROGEN GAS	195	
T1	155	.25	.004 .005	⊥	STATIC NITROGEN GAS	190	
T1	156	.25	.004 .005	⊥	STATIC NITROGEN GAS	190	
T1	157	.25	.004 .005	⊥	STATIC NITROGEN GAS	185	
T1	158	.25	.004 .005	⊥	STATIC NITROGEN GAS	195	
T1	170	.25	.004 .005	⊥	NITROGEN GAS IMPACT	330	
T1	171	.25	.004 .005	⊥	NITROGEN GAS IMPACT	260	
T1	172	.25	.004 .005	⊥	LIQ N₂ & N₂ GAS IMPACT	460	
T2	173	.25	.004 .005	∥	NITROGEN GAS IMPACT	320	
T2	174	.25	.004 .005	∥	NITROGEN GAS IMPACT	260	
T2	175	.25	.004 .005	∥	NITROGEN GAS IMPACT	260	
T2	176	.25	.004 .005	∥	NITROGEN GAS IMPACT	240	
T2	177	.25	.004 .005	∥	LIQ N₂ & N₂ GAS IMPACT	420	
T2	178	.25	.004 .005	∥	LIQ N₂ & N₂ GAS IMPACT	440	
T2	179	.25	.004 .005	∥	LIQ N₂ & N₂ GAS IMPACT	560	
T3	146	.25	.007 .008	⊥	STATIC NITROGEN GAS	370	
T3	147	.25	.007 .008	⊥	STATIC NITROGEN GAS	360	
T3	148	.25	.007 .008	⊥	STATIC NITROGEN GAS	360	
T3	149	.25	.007 .008	⊥	STATIC NITROGEN GAS	330	
T3	150	.25	.007 .008	⊥	STATIC NITROGEN GAS	350	
T3	151	.25	.007 .008	⊥	STATIC NITROGEN GAS	345	
T3	152	.25	.007 .008	⊥	STATIC NITROGEN GAS	400	
T3	159	.25	.007 .008	⊥	NITROGEN GAS IMPACT	455	CRACKED HINGE
T3	160	.25	.007 .008	⊥	NITROGEN GAS IMPACT	460	CRACKED HINGE
T3	161	.25	.007 .008	⊥	NITROGEN GAS IMPACT	470	PAD SEPARATED AT THE HINGE
T3	162	.25	.007 .008	⊥	NITROGEN GAS IMPACT	450	SEVERELY CRACKED HINGE
T3	163	.25	.007 .008	⊥	NITROGEN GAS IMPACT	500	CRACKED HINGE
T3	164	.25	.007 .008	⊥	NITROGEN GAS IMPACT	500	SEVERELY CRACKED HINGE
T3	165	.25	.007 .008	⊥	LIQ N₂ & N₂ GAS IMPACT	300	SEVERELY CRACKED HINGE
T3	166	.25	.007 .008	⊥	LIQ N₂ & N₂ GAS IMPACT	420	CRACKED HINGE
T3	167	.25	.007 .008	⊥	LIQ N₂ & N₂ GAS IMPACT	420	CRACKED HINGE
T3	168	.25	.007 .008	⊥	LIQ N₂ & N₂ GAS IMPACT	440	CRACKED HINGE
T3	169	.25	.007 .008	⊥	LIQ N₂ & N₂ GAS IMPACT	420	CRACKED HINGE

TABLE IV

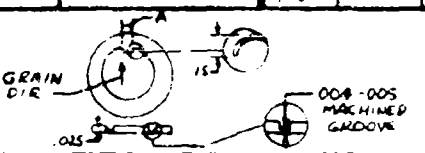
VERNIER LIQUID OXYGEN BURST

DIAPHRAGM BURST TEST RESULTS

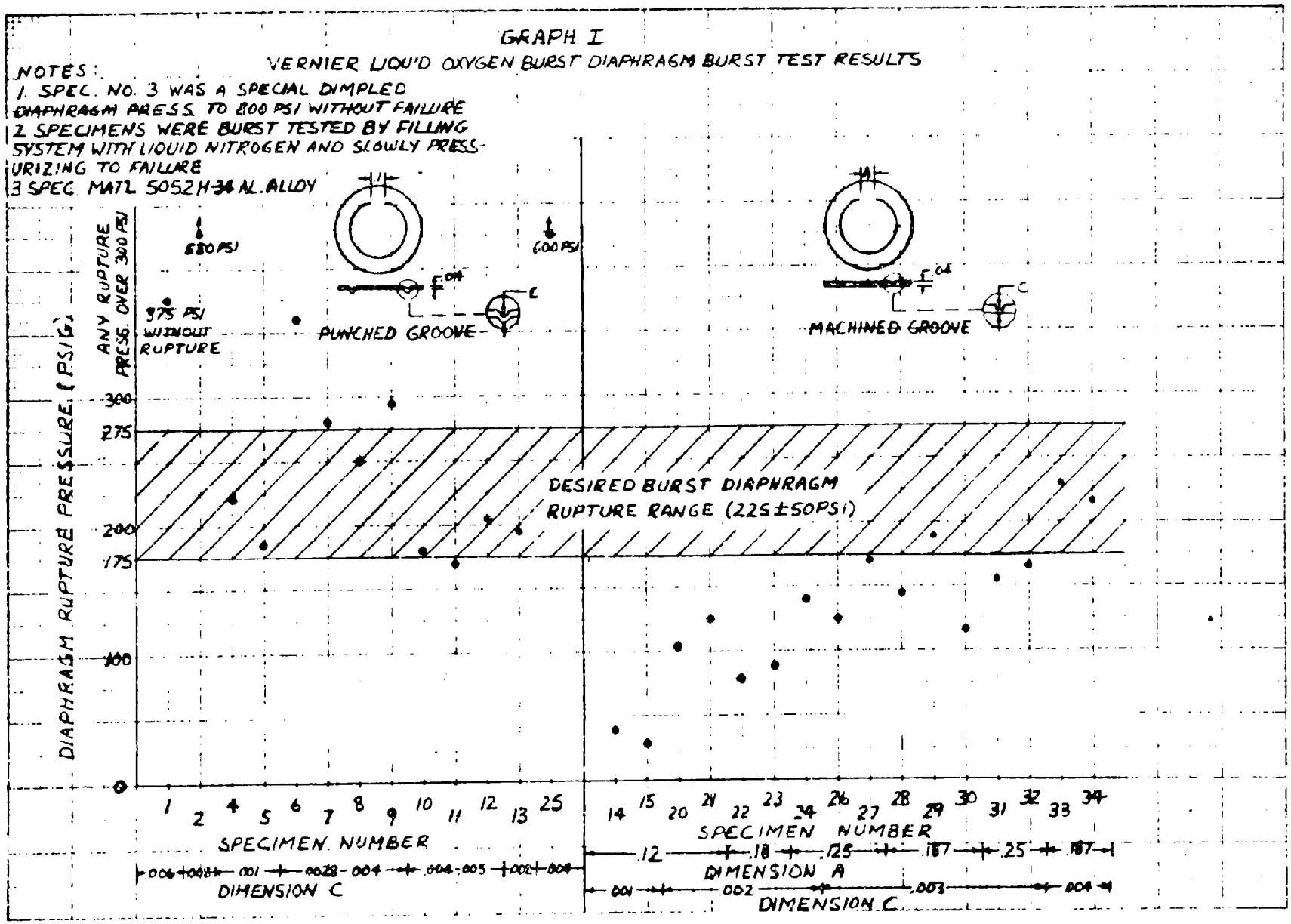
NOTES:
1 SPEC MAT'L 5052-H34 AL ALLOY
2 SPECIMENS WERE TESTED BY ONE OF THE FOLLOWING METHODS
A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
B) IMPACTING SPECIMEN WITH NITROGEN GAS
C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS

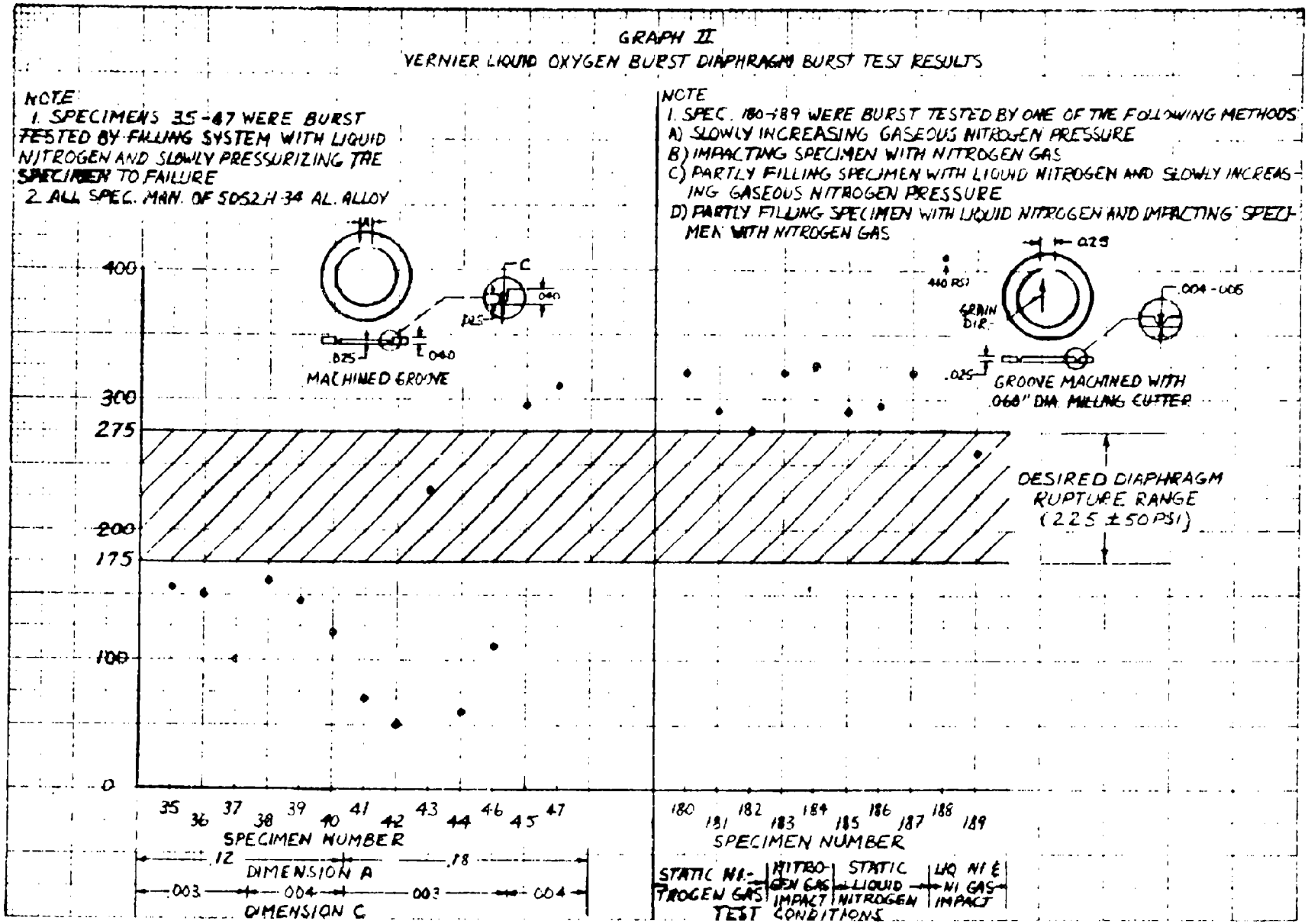


DESIGN GR IDEN. NO	TEST LAB IDEN NO	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
TI-1	190	STATIC NITROGEN GAS	190	
TI-2	191	STATIC NITROGEN GAS	195	
TI-3	192	NITROGEN GAS IMPACT	250	
TI-4	193	NITROGEN GAS IMPACT	250	
10	198	NITROGEN GAS IMPACT	320	
10	199	NITROGEN GAS IMPACT	300	
10	200	NITROGEN GAS IMPACT	280	
TI-5	194	STATIC LIQUID NITROGEN	185	
TI-6	195	STATIC LIQUID NITROGEN	185	
TI-7	196	LIQ NI & NI GAS IMPACT	310	
TI-8	197	LIQ NI & NI GAS IMPACT	390	
10	201	LIQ NI & NI GAS IMPACT	460	
10	202	LIQ NI & NI GAS IMPACT	410	
10	203	LIQ NI & NI GAS IMPACT	360	



DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
10-3	204	.25	NITROGEN GAS IMPACT	320	
10-3	205	.25	NITROGEN GAS IMPACT	280	
10-3	206	.25	NITROGEN GAS IMPACT	350	
10-3	207	.25	NITROGEN GAS IMPACT	310	
10-3	208	.25	NITROGEN GAS IMPACT	260	
10-1	213	.125	NITROGEN GAS IMPACT	300	
10-1	214	.125	NITROGEN GAS IMPACT	330	
10-1	215	.125	NITROGEN GAS IMPACT	290	
10-4	216	.125	NITROGEN GAS IMPACT	300	
10-3	209	.25	LIQ NI & NI GAS IMPACT	380	
10-3	210	.25	LIQ. NI & NI GAS IMPACT	340	
10-3	211	.25	LIQ. NI & NI GAS IMPACT	400	
10-3	212	.25	LIQ NI & NI GAS IMPACT	340	
10-1	217	.125	LIQ NI & NI GAS IMPACT	260	
10-1	218	.125	LIQ NI & NI GAS IMPACT	330	
10-1	219	.125	LIQ NI & NI GAS IMPACT	390	


GRAPH I
VERNIER LIQU'D OXYGEN BURST DIAPHRAGM BURST TEST RESULTS
NOTES:
1. SPEC. NO. 3 WAS A SPECIAL DIMPLED DIAPHRAGM PRESS. TO 800 PSI WITHOUT FAILURE
2. SPECIMENS WERE BURST TESTED BY FILLING SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING TO FAILURE
3 SPEC. MATL 5052 H-34 AL. ALLOY
DIAPHRAGM RUPTURE PRESSURE (PSIG)
ANY RUPTURE PRESS. OVER 300 PSI
800 PSI
975 PSI WITHOUT RUPTURE
600 PSI
PUNCHED GROOVE
MACHINED GROOVE
DESIRED BURST DIAPHRAGM RUPTURE RANGE (225±50PSI)
300
275
200
175
100
0
1 2 4 5 6 7 8 9 10 11 12 13 25
SPECIMEN NUMBER
.006 .008 .001 .0028 .004 .004 .005 .002 .009
DIMENSION C
14 15 20 21 22 23 24 26 27 28 29 30 31 32 33 34
SPECIMEN NUMBER
.12 .18 .125 .187 .25 .187
DIMENSION A
.001 .002 .003 .004
DIMENSION C

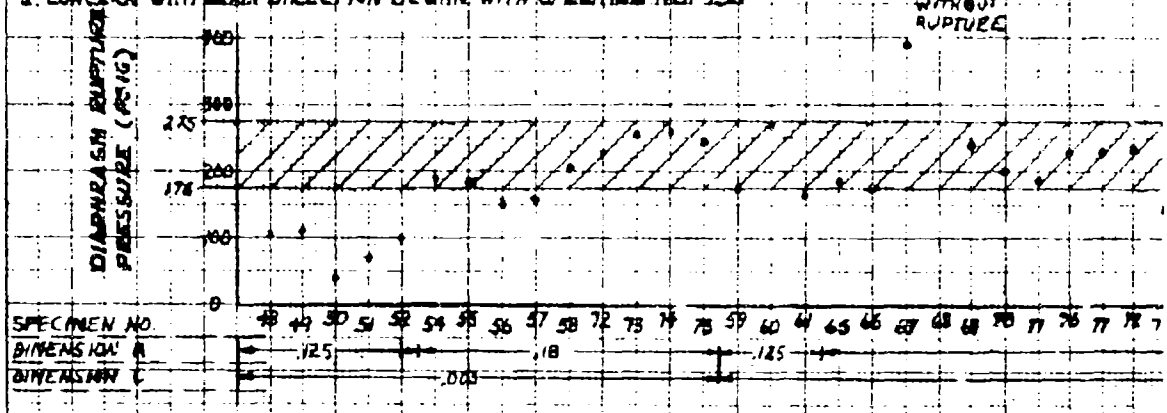

GRAPH II
VERNIER LIQUID OXYGEN BURST DIAPHRAGM BURST TEST RESULTS
NOTE
1. SPECIMENS 35-47 WERE BURST TESTED BY FILLING SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE
2. ALL SPEC. MAN. OF 5052-H-34 AL. ALLOY
NOTE
1. SPEC. 180-189 WERE BURST TESTED BY ONE OF THE FOLLOWING METHODS
A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
B) IMPACTING SPECIMEN WITH NITROGEN GAS
C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS
MACHINED GROOVE
GROOVE MACHINED WITH .060" DIA. MILLING CUTTER
GRAIN DIR.
440 RSI
400
300
275
200
175
100
0
DESIRED DIAPHRAGM RUPTURE RANGE (225 ± 50 PSI)
35 36 37 38 39 40 41 42 43 44 46 45 47
SPECIMEN NUMBER
180 181 182 183 184 185 186 187 188 189
SPECIMEN NUMBER
DIMENSION A
DIMENSION C
.003 .004 .003 .004
STATIC NITROGEN GAS
NITROGEN GAS IMPACT
STATIC LIQUID NITROGEN
LIQ NITROGEN GAS IMPACT
TEST CONDITIONS

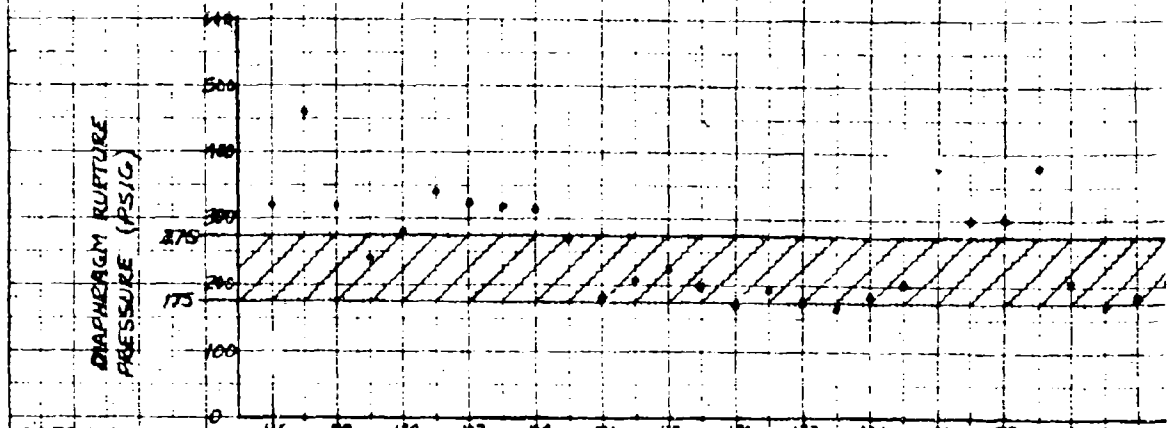
GRAPH

VERNIER LIQUID OXYG

NOTES:

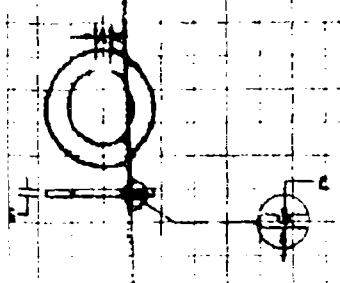
1. ALL SPECIMENS WERE FABRICATED FROM 5052H-34 ALUMINUM ALLOY
2. SPECIMENS 48 TO 116 PLUS 125 TO 130 WERE BURST TESTED BY ~~FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE~~ SPECIMEN TO FAILURE. THE REMAINING SPECIMENS WERE BURST TESTED BY ONE OF THE FOLLOWING METHODS
   - A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
   - B) IMPACTING SPECIMEN WITH NITROGEN GAS
   - C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
   - D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS (EXCEPT SPEC. # 116 & 128 WHICH WERE FULL OF LIQUID NITROGEN)
3. CONCERN WITH GRAIN DIRECTION BEGAN WITH SPECIMEN NO. 130





A

RAPH III
OXYGEN BURST DIAPHRAGM BURST TEST RESULTS



DESIRED BURST DIAPHRAGM RUPTURE RANGE (325 ± 50 PSI)

DESIRED BURST DIAPHRAGM RUPTURE RANGE (325 ± 50 PSI)

.25

.007 - .008

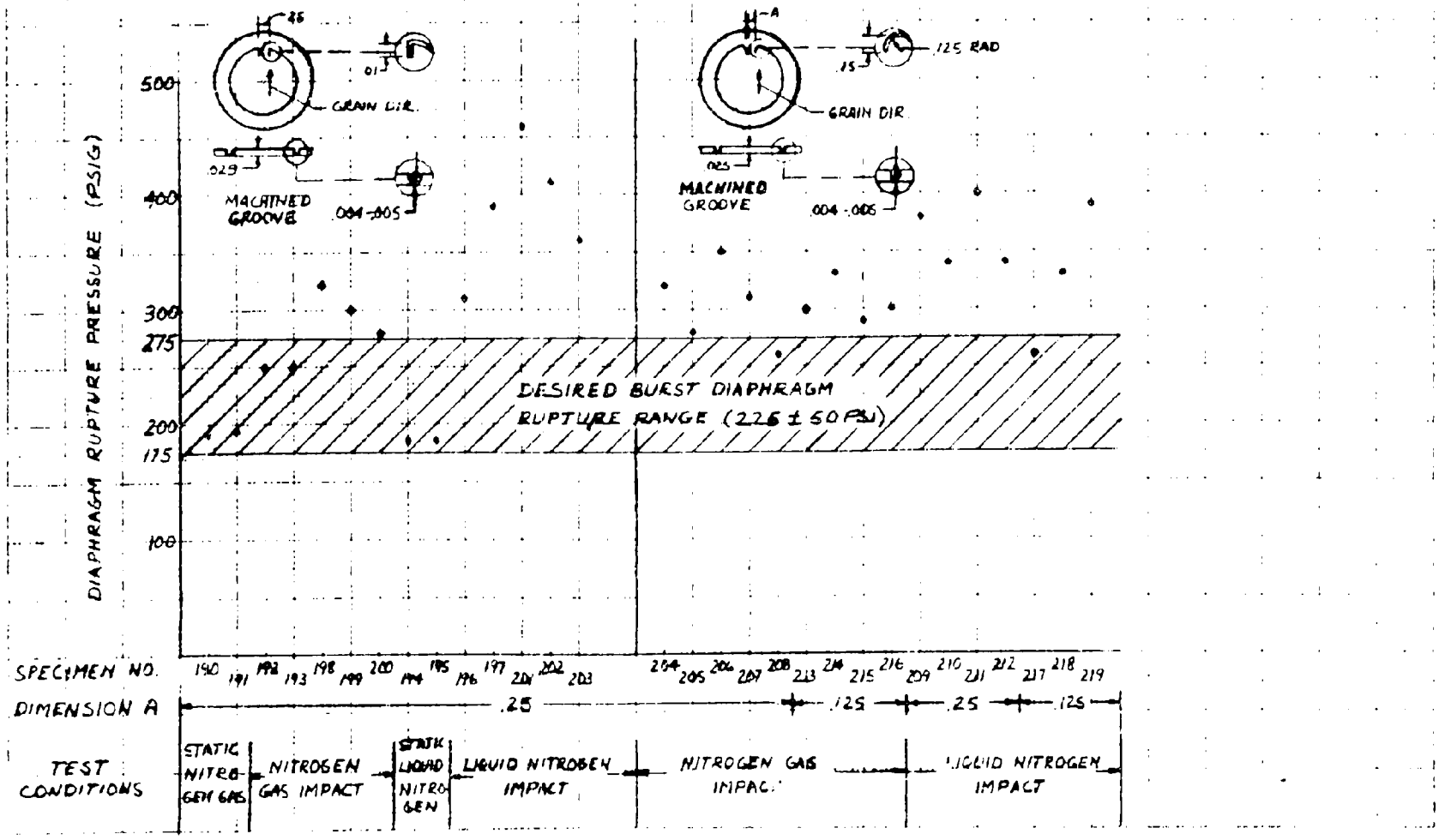
PERPENDICULAR TO HINGE — PARALLEL — GRAIN PERPENDICULAR TO HINGE

FATIG NITROGEN GAS — NI. GAS IMPACT — NITROGEN GAS IMPACT — LIQ. NI. + GAS NI IMPACT — STATIC NI — NITROGEN GAS IMPACT — LIQ. NI. + NI. GAS IMPACT

GRAPH IV

VERNIER LIQUID OXYGEN BURST DIAPHRAGM BURST TEST RESULTS

NOTES:
1. SPEC MAT'L 5052-H34 AL ALLOY
2. THE SPECIMENS WERE TESTED BY ONE OF THE FOLLOWING METHODS
   A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
   B) IMPACTING SPECIMEN WITH NITROGEN GAS
   C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
   D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS



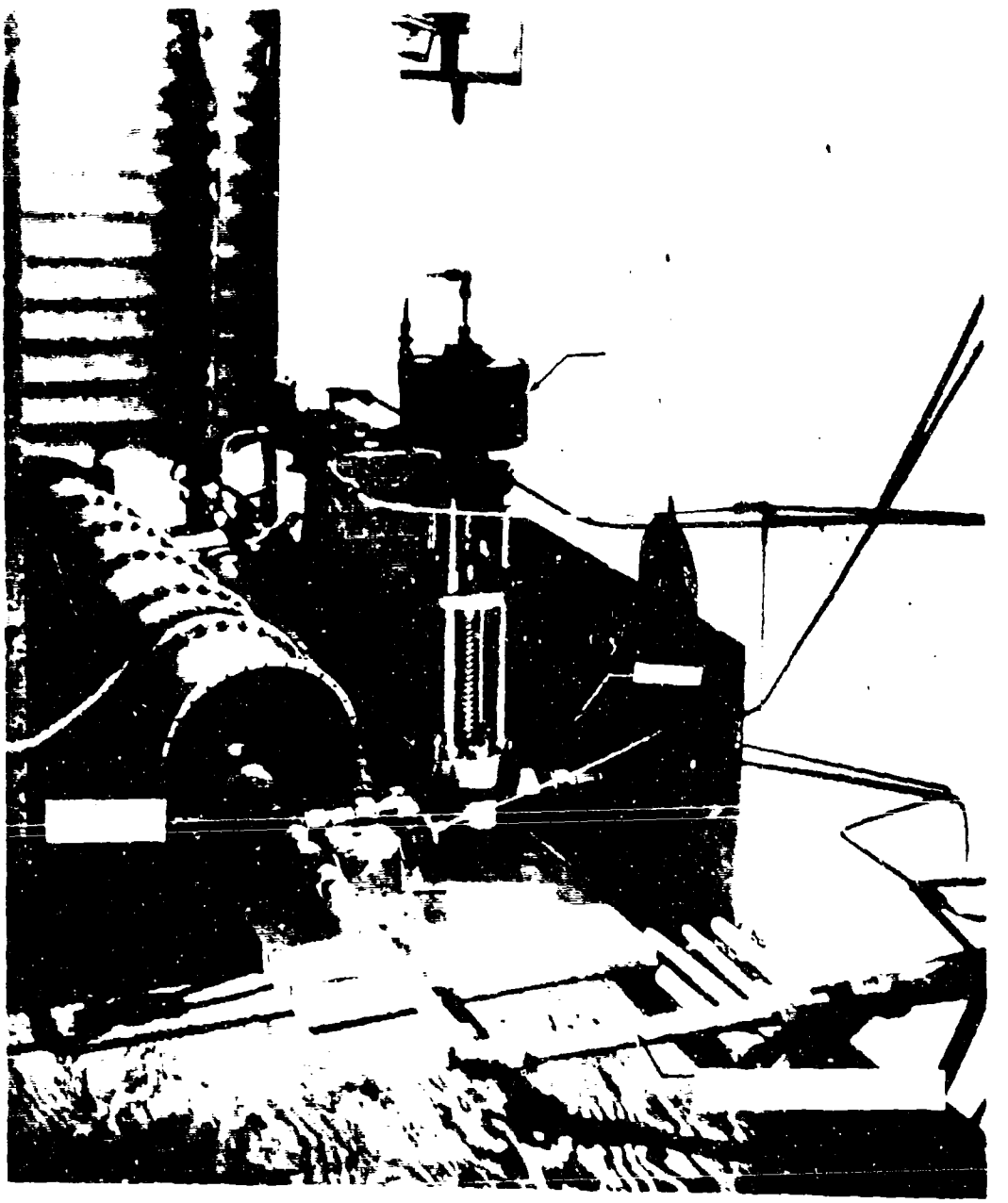


FIGURE 1

BURST TEST SETUP

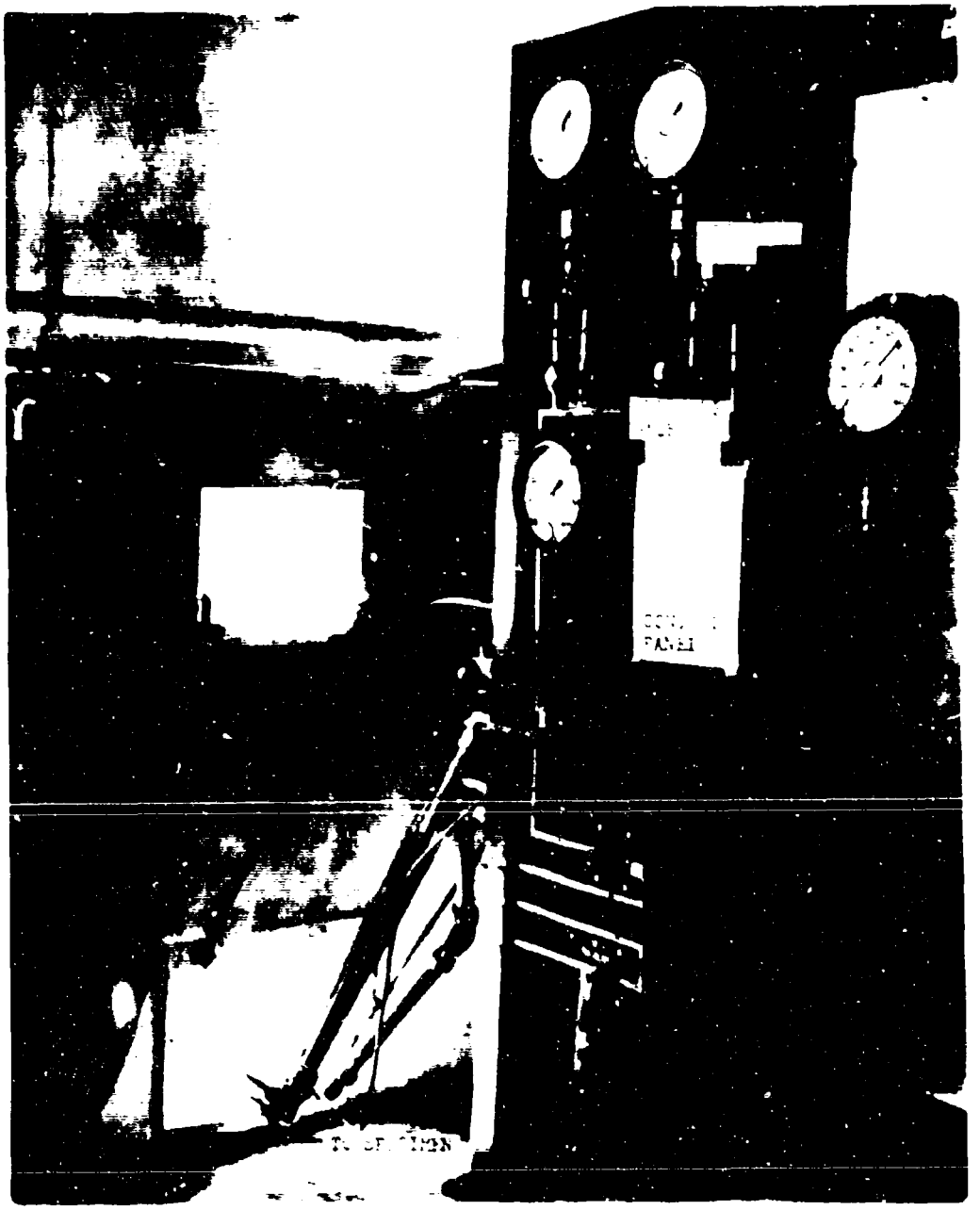


FIGURE 2

BURST TEST CONTROL PANEL

FIGURE 3

WATER FLOW SETUP